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HUMAN CENTRAL NERVOUS SYSTEM OXYGEN TOXICITY DATA  
FROM 1945 TO 1986

A. L. Harabin

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Naval Medical Research  
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Bethesda, Maryland 20889-5606

Department of the Navy  
Naval Medical Command  
Washington, DC 20372-5210

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## **TECHNICAL REVIEW AND APPROVAL**

**NMRI 93-03**

The experiments reported herein were conducted according to the principles set forth in the current edition of the "Guide for the Care and Use of Laboratory Animals," Institute of Laboratory Animal Resources, National Research Council.

This technical report has been reviewed by the NMRI scientific and public affairs staff and is approved for publication. It is releasable to the National Technical Information Service where it will be available to the general public, including foreign nations.

**ROBERT G. WALTER  
CAPT, DC, USN  
Commanding Officer  
Naval Medical Research Institute**

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## TABLE OF CONTENTS

ABSTRACT . . . . .	i
ACKNOWLEDGEMENTS . . . . .	iii
INTRODUCTION . . . . .	1
Data Format . . . . .	1
Table 1 . . . . .	3
DRY, NO EXERCISE (OLD) . . . . .	4
Yarbrough O.D. et al., 1947 . . . . .	4
Donald K.W., 1946 . . . . .	8
Behnke A.R. et al., 1935 . . . . .	11
White W.A., 1945 . . . . .	12
DRY, EXERCISE (OLD) . . . . .	14
Hayter R. and White W.A., 1946 . . . . .	14
Young J.M., 1971 . . . . .	15
IMMERSED, NO EXERCISE (OLD) . . . . .	41
Donald K.W., 1946 . . . . .	41
Yarbrough O.D. et al, 1947 . . . . .	64
IMMERSED, EXERCISE (OLD) . . . . .	78
Donald K.W., 1946 . . . . .	78
Schaefer K.E. et al., 1949 . . . . .	87
Lanphier E.H. and Dwyer J.V., 1945 . . . . .	90
Alexander J.M. and Flynn E.T., 1971 . . . . .	94
IMMERSED, EXERCISE (NEW) . . . . .	95
Piantadosi C.A. et al., 1979 . . . . .	95
Schwartz H.J.C., 1984 . . . . .	96
Butler F.K. and Thalmann E.D., 1984 . . . . .	97
Butler F.K. and Thalmann E.D., 1984 . . . . .	99
Butler F.K. and Thalmann E.D., 1986 . . . . .	101
Butler F.K. and Thalmann E.D., 1986 . . . . .	119
Butler F.K., 1986 . . . . .	126
REFERENCES . . . . .	137

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## INTRODUCTION

This report contains a summary and raw data of all known controlled human exposures to hyperbaric O<sub>2</sub>. The data were collected for analysis and development of predictive models relating the risk of developing a symptom of central nervous system O<sub>2</sub> toxicity to exposure depth, duration and condition. Data were obtained from publications, technical reports and verified by original records and log books. A total of 2,170 exposures, at depths ranging from 12 feet of sea water (fsw) to 100 fsw for up to 240 min are included. The data consist of exposure time, depth, fraction inspired O<sub>2</sub>, temperature, whether or not subjects exercised, whether they were immersed in water or exposed in a dry chamber, and outcome of the exposure, i.e., whether a symptom developed or the exposure was completed safely. Studies conducted under the following conditions were found: dry, no exercise; dry, exercise; immersed, no exercise; immersed, exercise; the final category was divided into old (before 1972) and new.

Data were obtained from 14 separate studies and divided into 20 files. An exact literature citation introduces each file. When published summaries were supplemented by original notebooks and logs this is also noted.. When there were differences in detail, the results from the primary references were used.

### Data Format

Each 2 line entry contains the results of 1 human exposure.

The first line describes the conditions and outcome of the exposure and the second line describes the exposure profile.

First data line: contains 7 entries with the following significance:

1. Outcome: safe (0), exposure-stopping symptom (1), symptom reported, exposure completed (0.5)
2. Wet (1)/ Dry (0)
3. Exposure temperature (°F)
4. not used
5. Exercise level (none (0), some (1-3))
6. not used
7. Fraction inspired oxygen

Second data line:

$t_1, d_1, t_2, d_2, \dots, t_n, d_n, 0, 0, t_{s1}, s_1, t_{s2}, s_2, \dots, t_{sn}, s_n$

where  $t_n$  is time (min),  $d_n$  is depth (feet of sea water) of the nth portion of multi-depth exposure;  $t_{sn}$  is time of nth symptom,  $s_n$  is nature of nth symptom; n can be 1 for single depth, single symptom exposures.

Symptom type ( $s_n$ ) was coded as follows:

1. nausea
2. irritability, dyspnea, sleepiness or dysphoria
3. headache
4. numbness, tingling
5. dizziness, vertigo
6. twitch
7. hearing disturbance



8. visual disturbance
9. unconsciousness, aphasia
10. convulsion

Table 1 is a summary of the data set.

TABLE 1			
DATA SET	DEPTH (fsw)	TIMES (min)	Ndat
Dry, No Exercise (Old)			
Yarbrough, 1947	100, 80, 60	120-40	76
Donald, 1947	90, 60	100	42
Behnke, 1935	99, 66, 33	180-45	9
White, 1945	100	60	17
Dry, Exercise (Old)			
Young, 1971	47-20	29-52	431
Hayter and White, 1946	62	43-180	13
Immersed, No Exercise (Old)			
Donald, 1945	103-28	57-120	399
Yarbrough, 1947	100, 80, 60	20-120	220
Immersed, Exercise (Old)			
Donald, 1945	53-28	80-120	161
Schaefer, 1949	40, 30, 20	1.5-75	49
Lanphier, 1954	50-20	15-113	56
Alexander, 1971	13	240	9
Immersed, Exercise (New)			
Piantadosi, 1979	25	240	12
Schwartz, 1984	30	90-220	18
Butler, 1984, 1986	50-20	5-240	658
			2170

# DRY, NO EXERCISE (OLD)

Citation: Yarbrough, O.D., W. Welham, E.S. Brinton, and A.R. Behnke. Symptoms of O<sub>2</sub> poisoning and limits of tolerance at rest and at work. Naval Experimental Diving Unit Research Report 01-47, Washington, D.C.: Naval Experimental Diving Unit, 1947 + Original records.

0, 0, 85, 0, 0, 0, .9,  
119, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
60, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
129, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
121, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
120, 50, 0,0,

0, 0, 85, 0, 0, 0, .9,  
119, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
120, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
129, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
120, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
120, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
120, 60, 0,0,

0, 0, 85, 0, 0, 0, .9,  
121, 60, 0,0,

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129, 60, 0,0,

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28, 80, 0,0, 28,5

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10, 80, 0,0, 10,8, 10,5, 10,1

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72, 80, 0,0, 72,7, 72,4, 72,1

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31, 80, 0,0, 31,6, 31,1,

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79, 80, 0,0, 79,5, 79,1

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79, 80, 0,0, 79,8, 79,6, 79,5

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 8, 100, 0,0, 8,9, 8,7,

Citation: Donald, K.W. Variation in the O<sub>2</sub> tolerance of human subjects in the wet and in the dry. O<sub>2</sub> Poisoning in Man. Admiralty Experimental Diving Unit Technical Report No. 16. HMS Vernon, Portsmouth, UK, 1946.

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6, 90, 0, 0, 1, 6,	6, 1,	
1, 0, 70, 0, 0, 0, .95,		
6, 90, 0, 0, 3, 6,	6, 6,	

Citation: Behnke, A.R., F.S. Johnson, J.R. Poppen, E.P. Motley.  
The effect of oxygen on man at pressures from 1 to 4  
atmospheres. J. Physiol. 110: 562-572, 1935.

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43, 99, 0,0, 43, 9,	
1, 0, 73, 2, 0, 0, .9,	
44, 99, 0,0, 44, 10,	

Citation: White, W.A. O<sub>2</sub> Poisoning in Man. Effect of cystein hydrochloride and ammonium chloride on the time of onset of toxic symptoms. Naval Medical Research Institute Technical Report No. 1, Bethesda, MD: Naval Medical Research Institute, 1945.

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32, 100, 0,0, 32, 5,

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1, 0, 75, 2, 2, 0, .9,  
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16, 62, 0,0, 16, 6,

1, 0, 75, 2, 2, 0, .9,  
18, 62, 0,0, 18, 6,

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46, 32, 0, 0, 6, 6, 35, 6,

1.0, 0, 81, 0, 2, 0, .84,  
43, 32, 0, 0, 3, 6, 43, 6,

1.0, 0, 80, 0, 2, 0, .84,  
40, 32, 0, 0, 5, 6, 14, 6,

1.0, 0, 82, 0, 2, 0, .84,  
41, 32, 0, 0, 15, 6, 41, 6,

1.0, 0, 83, 0, 2, 0, .84,  
42, 32, 0, 0, 6, 6, 42, 6,

1.0, 0, 83, 0, 2, 0, .84,  
47, 32, 0, 0, 7, 6, 47, 6,

1.0, 0, 84, 0, 2, 0, .84,  
45, 32, 0, 0, 8, 6, 45, 6,

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43, 32, 0, 0, 12, 6, 43, 6,

1.0, 0, 83, 0, 2, 0, .84,  
40, 32, 0, 0, 11, 6, 17, 6, 25, 5, 40, 5,

1.0, 0, 85, 0, 2, 0, .84,  
40, 32, 0, 0, 7, 4,

0.0, 0, 82, 0, 2, 0, .84,  
40, 32, 0, 0,



1.0,	0, 83,	0,	2,	0, .84,		
44, 32,	0,	0,	4,	6,	44,	6,
0.5,	0, 80,	0,	2,	0, .84,		
43, 32,	0,	0,	40,	6,		
1.0,	0, 84,	0,	2,	0, .84,		
46, 32,	0,	0,	8,	6,	46,	6,
1.0,	0, 82,	0,	2,	0, .84,		
40, 32,	0,	0,	25,	6,	31,	6,
0.0,	0, 83,	0,	2,	0, .84,		
40, 32,	0,	0,				
0.0,	0, 84,	0,	2,	0, .84,		
40, 32,	0,	0,				
0.0,	0, 83,	0,	2,	0, .84,		
40, 32,	0,	0,				
1.0,	0, 83,	0,	2,	62, .84,		
45, 32,	0,	0,	10,	6,	45,	6,
1.0,	0, 84,	0,	2,	0, .84,		
45, 32,	0,	0,	2,	6,	45,	6,
1.0,	0, 84,	0,	2,	0, .84,		
40, 32,	0,	0,	40,	6,		
0.0,	0, 83,	0,	2,	0, .84,		
40, 32,	0,	0,				
1.0,	0, 82,	0,	2,	0, .84,		
43, 32,	0,	0,	3,	6,	44,	6,
1.0,	0, 83,	0,	2,	0, .84,		
43, 32,	0,	0,	4,	6,	43,	6,
1.0,	0, 77,	0,	2,	0, .84,		
48, 32,	0,	0,	6,	6,	48,	6,
1.0,	0, 84,	0,	2,	0, .84,		
43, 32,	0,	0,	4,	6,	43,	6,
0.0,	0, 80,	0,	2,	0, .84,		
40, 32,	0,	0,				
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 41, 35, 0, 0, 28, 5, 41, 5,

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 43, 35, 0, 0, 6, 6, 43, 6,

0.0, 0, 84, 0, 2, 0, .84,  
 40, 35, 0, 0,

0.0, 0, 82, 0, 2, 0, .84,  
 45, 35, 0, 0,

1.0,	0, 85,	0, 2,	0, .84,		
45, 35,	0, 0,	2, 6,	45, 6,	41, 1,	
0.0,	0, 84,	0, 2,	0, .84,		
40, 35,	0, 0,				
1.0,	0, 78,	0, 2,	0, .84,		
46, 35,	0, 0,	29, 6,	46, 6,		
1.0,	0, 83,	0, 2,	0, .84,		
47, 35,	0, 0,	7, 6,	47, 6,		
1.0,	0, 77,	0, 2,	0, .84,		
42, 35,	0, 0,	10, 6,	42, 6,		
1.0,	0, 83,	0, 2,	0, .84,		
49, 35,	0, 0,	31, 6,	49, 6,		
1.0,	0, 79,	0, 2,	0, .84,		
45, 35,	0, 0,	5, 6,	45, 6,		
1.0,	0, 82,	0, 2,	0, .84,		
41, 35,	0, 0,	5, 6,	41, 6,		
1.0,	0, 83,	0, 2,	0, .84,		
42, 35,	0, 0,	3, 6,	42, 6,		
1.0,	0, 82,	0, 2,	0, .84,		
44, 35,	0, 0,	5, 6,	41, 6,	38, 2,	
0.0,	0, 80,	0, 2,	62, .84,		
41, 35,	0, 0,				
1.0,	0, 82,	0, 2,	0, .84,		
45, 35,	0, 0,	9, 6,	45, 6,		
0.5,	0, 83,	0, 2,	0, .84,		
40, 35,	0, 0,	14, 6,			
0.0,	0, 79,	0, 2,	0, .84,		
46, 35,	0, 0,				
1.0,	0, 76,	0, 2,	0, .84,		
40, 35,	0, 0,	15, 6,	17, 6,		
1.0,	0, 83,	0, 2,	0, .84,		
42, 35,	0, 0,	17, 6,	42, 6,		
0.0,	0, 84,	0, 2,	0, .84,		
40, 35,	0, 0,				

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 43, 35, 0, 0, 5, 6, 41, 6,  
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 46, 35, 0, 0, 46, 6,  
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 44, 35, 0, 0, 5, 6, 44, 6,  
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 41, 35, 0, 0, 3, 4, 41, 4,  
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 43, 38, 0, 0,  
 0.0, 0, 83, 0, 2, 0, .84,  
 45, 38, 0, 0,

1.0,	0, 80,	0,	2,	0, .84,	
41, 38,	0,	0,	20,	6,	41, 6,
0.0,	0, 82,	0,	2,	0, .84,	
42, 38,	0,	0,			
0.5,	0, 83,	0,	2,	0, .84,	
41, 38,	0,	0,	41,	6,	
0.5,	0, 79,	0,	2,	0, .84,	
43, 38,	0,	0,	42,	6,	
0.0,	0, 80,	0,	2,	0, .84,	
41, 38,	0,	0,			
0.0,	0, 83,	0,	2,	0, .84,	
44, 38,	0,	0,			
1.0,	0, 82,	0,	2,	0, .84,	
45, 38,	0,	0,	4,	6,	45, 6,
1.0,	0, 83,	0,	2,	0, .84,	
45, 38,	0,	0,	11,	6,	45, 6,
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45, 38,	0,	0,	45,	1,	
1.0,	0, 83,	0,	2,	0, .84,	
45, 38,	0,	0,	8,	6,	45, 6,
0.0,	0, 83,	0,	2,	0, .84,	
43, 38,	0,	0,			
1.0,	0, 80,	0,	2,	0, .84,	
43, 38,	0,	0,	10,	6,	43, 6,
1.0,	0, 82,	0,	2,	0, .84,	
42, 38,	0,	0,	16,	6,	26, 6,
1.0,	0, 77,	0,	2,	0, .84,	
45, 38,	0,	0,	10,	6,	21, 6,
1.0,	0, 83,	0,	2,	0, .84,	
45, 38,	0,	0,	14,	6,	45, 6,
0.0,	0, 83,	0,	2,	0, .84,	
41, 38,	0,	0,			
0.0,	0, 79,	0,	2,	0, .84,	
40, 38,	0,	0,			

1.0,	0, 82,	0,	2,	0, .84,					
45, 38,	0,	0,	3,	6,	45,	6,			
0.0,	0, 83,	0,	2,	0, .84,					
41, 38,	0,	0,							
1.0,	0, 83,	0,	2,	0, .84,					
45, 38,	0,	0,	27,	6,	30,	6,			
1.0,	0, 80,	0,	2,	0, .84,					
46, 38,	0,	0,	15,	5,	23,	5,	22,	6,	46,
0.0,	0, 82,	0,	2,	0, .84,					
44, 38,	0,	0,							
1.0,	0, 80,	0,	2,	0, .84,					
43, 38,	0,	0,	27,	6,	43,	9,			
0.0,	0, 80,	0,	2,	0, .84,					
43, 38,	0,	0,							
1.0,	0, 82,	0,	2,	0, .84,					
45, 38,	0,	0,	30,	6,	45,	6,			
1.0,	0, 83,	0,	2,	0, .84,					
44, 38,	0,	0,	7,	6,	43,	6,			
1.0,	0, 83,	0,	2,	0, .84,					
45, 38,	0,	0,	12,	6,	45,	6,			
1.0,	0, 80,	0,	2,	0, .84,					
39, 38,	0,	0,	39,	1,	39,	9,	26,	6,	
0.0,	0, 77,	0,	2,	0, .84,					
45, 38,	0,	0,							
1.0,	0, 80,	0,	2,	0, .84,					
43, 38,	0,	0,	8,	6,	27,	6,	35,	1,	40,
1.0,	0, 79,	0,	2,	0, .84,					
40, 38,	0,	0,	7,	6,	27,	5,	32,	5,	40,
0.0,	0, 82,	0,	2,	0, .84,					
45, 38,	0,	0,							
1.0,	0, 83,	0,	2,	0, .84,					
45, 38,	0,	0,	3,	6,	45,	6,			
1.0,	0, 82,	0,	2,	0, .84,					
43, 38,	0,	0,	3,	6,	43,	6,			

1.0,	0, 83,	0,	2,	0, .84,	
45, 38,	0, 0,		15,	6,	45, 6,
0.0,	0, 80,	0,	2,	0, .84,	
41, 38,	0, 0,				
1.0,	0, 81,	0,	2,	0, .84,	
41, 38,	0, 0,		20,	6,	
0.0,	0, 83,	0,	2,	0, .84,	
45, 38,	0, 0,				
0.5,	0, 82,	0,	2,	0, .84,	
44, 38,	0, 0,		6,	5,	
1.0,	0, 80,	0,	2,	0, .84,	
41, 38,	0, 0,		17,	6,	41, 6,
0.0,	0, 78,	0,	2,	0, .84,	
41, 41,	0, 0,				
1.0,	0, 80,	0,	2,	0, .84,	
45, 41,	0, 0,		17,	6,	45, 6,
0.0,	0, 81,	0,	2,	0, .84,	
41, 41,	0, 0,				
1.0,	0, 80,	0,	2,	0, .84,	
41, 41,	0, 0,		17,	6,	41, 6,
1.0,	0, 83,	0,	2,	0, .84,	
43, 41,	0, 0,		23,	1,	37, 5,
0.0,	0, 83,	0,	2,	0, .84,	
41, 41,	0, 0,				
1.0,	0, 82,	0,	2,	0, .84,	
45, 41,	0, 0,		12,	6,	45, 6,
1.0,	0, 84,	0,	2,	0, .84,	
42, 41,	0, 0,		40,	5,	
0.0,	0, 80,	0,	2,	0, .84,	
50, 41,	0, 0,				
0.0,	0, 80,	0,	2,	0, .84,	
43, 41,	0, 0,				
1.0,	0, 78,	0,	2,	0, .84,	
44, 41,	0, 0,		8,	6,	44, 6,

1.0, 0, 79, 0, 2, 0, .84,  
 41, 41, 0, 0, 29, 5, 41, 5,  
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 41, 41, 0, 0, 29, 2, 41, 2,  
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 40, 41, 0, 0, 32, 5,  
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 50, 41, 0, 0, 20, 6, 46, 6,  
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41, 41,	0,	0,					
0.0,	0, 75,	0,	2,	0,	.84,		
41, 41,	0,	0,					
1.0,	0, 83,	0,	2,	0,	.84,		
47, 41,	0,	0,	27,	6,		47,	6,
1.0,	0, 79,	0,	2,	62,	.84,		
45, 41,	0,	0,	9,	6,		45,	6,
						25,	1,
1.0,	0, 78,	0,	2,	0,	.84,		
41, 41,	0,	0,	27,	6,			
0.0,	0, 80,	0,	2,	0,	.84,		
41, 41,	0,	0,					
0.0,	0, 80,	0,	2,	0,	.84,		
41, 41,	0,	0,					
1.0,	0, 82,	0,	2,	0,	.84,		
44, 41,	0,	0,	17,	6,		44,	6,
1.0,	0, 81,	0,	2,	0,	.84,		
41, 41,	0,	0,	34,	1,			
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41, 44,	0,	0,					
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41, 44,	0,	0,					
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42, 44,	0,	0,					
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40, 44,	0,	0,	23,	6,			
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41, 44,	0,	0,					

0.0,	0, 82,	0,	2,	0,	.81,	
41, 44,	0,	0,				
1.0,	0, 80,	0,	2,	0,	.81,	
44, 44,	0,	0,	29,	1,	44,	1,
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43, 44,	0,	0,	6,	6,	43,	6,
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46, 44,	0,	0,	39,	1,	46,	6,
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43, 44,	0,	0,	9,	6,	44,	6,
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45, 44,	0,	0,	35,	6,	43,	6,
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47, 44,	0,	0,				
1.0,	0, 80,	0,	2,	0,	.81,	
40, 44,	0,	0,	18,	1,	38,	1,
0.0,	0, 80,	0,	2,	0,	.81,	
41, 44,	0,	0,				
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41, 44,	0,	0,	2,	6,	41,	6, 41, 10,
0.0,	0, 85,	0,	2,	0,	.81,	
41, 44,	0,	0,				
1.0,	0, 77,	0,	2,	0,	.62,	
48, 44,	0,	0,	20,	6,	48,	6,
1.0,	0, 83,	0,	2,	0,	.83,	
41, 44,	0,	0,	20,	5,	36,	5,
0.0,	0, 82,	0,	2,	0,	.81,	
41, 44,	0,	0,				
0.0,	0, 83,	0,	2,	0,	.81,	
41, 44,	0,	0,				
0.0,	0, 83,	0,	2,	0,	.84,	
41, 44,	0,	0,				
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 41, 47, 0, 0, 32, 1,

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 46, 47, 0, 0, 8, 6, 46, 6,

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 47, 47, 0, 0, 31, 6, 47, 6,

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 51, 47, 0, 0,

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 41, 47, 0, 0, 20, 5, 25, 5, 30, 1,

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 52, 47, 0, 0, 31, 1, 52, 1, 31, 5, 52, 5,

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 41, 47, 0, 0,

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41, 47,	0,	0,					
1.0,	0, 85,	0,	2,	0,	.83,		
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# IMMERSED, NO EXERCISE (OLD)

Citation: Donald, K.W. Variation in the O<sub>2</sub> tolerance of human subjects in the wet and in the dry. O<sub>2</sub> Poisoning in Man. Admiralty Experimental Diving Unit Technical Report No. 16. HMS Vernon, Portsmouth, UK, 1946.

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44, 28, 0,0, 44, 6,

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120, 60, 0,0,

# IMMERSED, EXERCISE (OLD)

Citation: Donald, K.W. Variation in the O<sub>2</sub> tolerance of human subjects in the wet and in the dry. O<sub>2</sub> Poisoning in Man. Admiralty Experimental Diving Unit Technical Report No. 16. HMS Vernon, Portsmouth, UK, 1946.

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32, 53, 0,0,	32, 10,
0, 1, 65, 2,	3, 0, .95,
48, 53, 0,0,	
1, 1, 65, 2,	3, 0, .95,
24, 53, 0,0,	24, 6,
1, 1, 65, 2,	3, 0, .95,
43, 53, 0,0,	43, 6,
1, 1, 65, 2,	3, 0, .95,
39, 53, 0,0,	39, 6,
1, 1, 65, 2,	3, 0, .95,
19, 53, 0,0,	19, 6,
1, 1, 65, 2,	3, 0, .95,
5, 53, 0,0,	5, 6,
1, 1, 65, 2,	3, 0, .95,
12, 53, 0,0,	12, 6,
1, 1, 65, 2,	3, 0, .95,
3, 53, 0,0,	3, 6,
1, 1, 65, 2,	3, 0, .95,
6, 53, 0,0,	6, 10,
1, 1, 65, 2,	3, 0, .95,
5, 53, 0,0,	5, 6,
1, 1, 65, 2,	3, 0, .95,
22, 53, 0,0,	22, 6,
1, 1, 65, 2,	3, 0, .95,
37, 53, 0,0,	37, 6,

1, 1, 65, 2, 3, 0, .95,  
56, 53, 0,0, 56, 10,

1, 1, 65, 2, 3, 0, .95,  
11, 53, 0,0, 11, 6,

1, 1, 65, 2, 3, 0, .95,  
12, 53, 0,0, 12, 6,

1, 1, 65, 2, 3, 0, .95,  
16, 53, 0,0, 16, 6,

1, 1, 65, 2, 3, 0, .95,  
40, 53, 0,0, 40, 6,

1, 1, 65, 2, 3, 0, .95,  
13, 53, 0,0, 13, 1,

1, 1, 65, 2, 3, 0, .95,  
29, 53, 0,0, 29, 1,

1, 1, 65, 2, 3, 0, .95,  
34, 53, 0,0, 34, 1,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

1, 1, 65, 2, 1, 0, .95,  
25, 53, 0,0, 25, 10,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

1, 1, 65, 2, 1, 0, .95,  
22, 53, 0,0, 22, 6,

1, 1, 65, 2, 1, 0, .95,  
13, 53, 0,0, 13, 5,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

1, 1, 65, 2, 1, 0, .95,  
9, 53, 0,0, 9, 6,

1, 1, 65, 2, 1, 0, .95,  
11, 53, 0,0, 11, 6,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

1, 1, 65, 2,	1, 0, .95,
11, 53, 0,0,	11, 5,
1, 1, 65, 2,	1, 0, .95,
19, 53, 0,0,	19, 10,
1, 1, 65, 2,	1, 0, .95,
16, 53, 0,0,	16, 6,
1, 1, 65, 2,	1, 0, .95,
28, 53, 0,0,	28, 6,
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
1, 1, 65, 2,	1, 0, .95,
10, 53, 0,0,	10, 10,
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
1, 1, 65, 2,	1, 0, .95,
20, 53, 0,0,	20, 6,
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
1, 1, 65, 2,	1, 0, .95,
27, 53, 0,0,	27, 10,
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
0, 1, 65, 2,	1, 0, .95,
30, 53, 0,0,	
1, 1, 65, 2,	1, 0, .95,
24, 53, 0,0,	24, 10,

1, 1, 65, 2, 1, 0, .95,  
27, 53, 0,0, 27, 10,

1, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0, 30, 6,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

1, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0, 30, 10,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

1, 1, 65, 2, 1, 0, .95,  
25, 53, 0,0, 25, 6,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

0, 1, 65, 2, 1, 0, .95,  
30, 53, 0,0,

1, 1, 65, 2, 1, 0, .95,  
27, 53, 0,0, 27, 10,

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Willmon. Studies of O<sub>2</sub> toxicity. Naval Submarine  
Medical Research Laboratory Technical Report No. 149;  
8: 89-43, New London, CT: U.S. Naval Submarine Base,  
1949.

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

0, 1, 90, 0, 1, 9.8, .80  
75, 20, 0,0,

1, 1, 90, 0, 1, 11.3, .80  
72, 20, 0,0, 72,1

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

0, 1, 90, 0, 1, 11.6, .80  
86, 30, 0,0,

1, 1, 90, 0, 1, 4.5, .80  
40, 30, 0,0, 40,6

1, 1, 90, 0, 1, 8.8, .80  
42, 30, 0,0, 42,2

1, 1, 90, 0, 1, 16.5, .80  
72, 30, 0,0, 72,2

1, 1, 90, 0, 1, 5.6, .80  
96, 30, 0,0, 96,1

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

0, 1, 90, 0, 1, 13.5, .80  
89, 40, 0,0,

1, 1, 90, 0, 1, 5.2, .80  
30, 40, 0,0, 30,10

1, 1, 90, 0, 1, 6.5, .80  
45, 40, 0,0, 45, 1

1, 1, 90, 0, 1, 6.0, .80  
63, 40, 0,0, 63, 6

1, 1, 90, 0, 1, 35, .80  
45, 40, 0,0, 45,6

1, 1, 90, 0, 1, 32, .80  
88, 40, 0,0, 88,2

1, 1, 90, 0, 1, 18.7, .80  
82, 40, 0,0, 82, 10

1, 1, 90, 0, 1, 10.9, .80  
55, 40, 0,0, 55, 9

1, 1, 90, 0, 1, 20.7, .80  
89, 40, 0,0, 89, 2

Citation: Lanphier, E.H., and J.V. Dwyer. Diving with the  
self-contained underwater breathing apparatus. Naval  
Experimental Diving Unit Technical Report No. 11-54,  
Washington, D.C.: Naval Experimental Diving Unit, 1954  
+ Original records.

0, 1, 80, 0, 2, 0, .9,  
57, 30, 0,0,

0, 1, 80, 0, 2, 0, .9,  
11, 50, 0,0,

0, 1, 80, 0, 2, 0, .9,  
12, 50, 0,0,



0, 1, 80, 0, 2, 0, .9,  
57, 30, 0,0,

0, 1, 80, 0, 2, 0, .9,  
31, 40, 0,0,

0, 1, 80, 0, 2, 0, .9,  
53, 30, 0,0,

0, 1, 80, 0, 2, 0, .9,  
113, 20, 0,0,

1, 1, 80, 0, 2, 0, .9,  
15, 50, 0,0, 15, 9

1, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0, 30, 10,

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

1, 1, 80, 0, 2, 0, .9,  
18, 40, 0,0, 18, 1,

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

1, 1, 80, 0, 2, 0, .9,  
17, 40, 0,0, 17,5

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

0, 1, 80, 0, 2, 0, .9,  
57, 30, 0,0,

0, 1, 80, 0, 2, 0, .9,  
8, 30, 0,0,

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

0,	1,	80,	0,	2,	0,	.9,
30,	40,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
30,	40,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
30,	40,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
57,	30,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
57,	30,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
57,	30,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
57,	30,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
57,	30,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
57,	30,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
113,	20,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
113,	20,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
113,	20,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
113,	20,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
113,	20,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
113,	20,	0,0,				
0,	1,	80,	0,	2,	0,	.9,
113,	20,	0,0,				

0, 1, 80, 0, 2, 0, .9,  
 19, 45, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 113, 20, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 19, 45, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 19, 45, 0,0,  
  
 1, 1, 80, 0, 2, 0, .9,  
 10, 45, 0,0, 10, 7,  
  
 1, 1, 80, 0, 2, 0, .9,  
 28, 35, 0,0, 28, 1,  
  
 0, 1, 80, 0, 2, 0, .9,  
 43, 35, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 42, 35, 0,0,  
  
 1, 1, 80, 0, 2, 0, .9,  
 42, 35, 0,0, 42, 10,  
  
 0, 1, 80, 0, 2, 0, .9,  
 43, 35, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 81, 25, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 81, 25, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 81, 25, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 81, 25, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 30, 40, 0,0,  
  
 0, 1, 80, 0, 2, 0, .9,  
 19, 45, 0,0,

0, 1, 80, 0, 2, 0, .9,  
30, 40, 0,0,

0, 1, 80, 0, 2, 0, .9,  
19, 45, 0,0,

1, 1, 90, 0, 1, 5.6, .80  
45, 40, 0,0, 45, 2

Citation: Alexander, J.M. and E.T. Flynn. Report of nine 4 hour exposures to 100% O<sub>2</sub> at 11-13 fsw. Naval Experimental Diving Unit Technical Report No. 9-71, Washington, D.C.: Naval Experimental Diving Unit, 1971.

0, 1, 86, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 83, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 83, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 87, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 87, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 86, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 83, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 86, 2, 2, 0, .95,  
240, 12, 0,0,

0, 1, 86, 2, 2, 0, .95,  
240, 12, 0,0,

# IMMERSED, EXERCISE (NEW)

Citation: Piantadosi, C.A., R.L. Clinton, E.D. Thalmann.  
Prolonged oxygen exposures in immersed exercising  
divers at 25 fsw (1.76 ATA). Undersea Biomed. Res. 6:  
347-356, 1979 + Original records.

0, 1, 70, 1, 1, 0, .95,  
176, 25, 0,0,

0, 1, 70, 1, 1, 0, .95,  
248, 25, 0,0,

0, 1, 70, 1, 1, 0, .95,  
252, 25, 0,0,

0, 1, 70, 1, 1, 0, .95,  
268, 25, 0,0,

.5, 1, 70, 1, 1, 0, .95,  
175, 25, 0,0, 175, 7,

0, 1, 70, 1, 1, 0, .95,  
252, 25, 0,0,

0, 1, 70, 2, 2, 0, .95,  
86, 25, 0,0,

0, 1, 70, 2, 2, 0, .95,  
68, 25, 0,0,

0, 1, 70, 2, 2, 0, .95,  
79, 25, 0,0,

0, 1, 70, 2, 2, 0, .95,  
82, 25, 0,0,

0, 1, 70, 2, 2, 0, .95,  
79, 25, 0,0,

0, 1, 70, 2, 2, 0, .95,  
81, 25, 0,0,

Citation: Schwartz, H.J.C. Manned testing of two closed-circuit oxygen underwater breathing apparatus: U.S. Navy Emerson rig and Fenzy PO. 68. Naval Experimental Diving Unit Technical Report No. 13-84, Panama City, FL: Naval Experimental Diving Unit, 1984 + Original records.

0, 1, 70, 1, 1, 0, .98  
250, 30, 0,0,

0, 1, 70, 1, 1, 0, .98  
254, 30, 0,0,

0, 1, 70, 1, 1, 0, .98  
244, 30, 0,0,

1, 1, 70, 1, 1, 0, .98  
152, 30, 0,0, 152, 5, 152,2

1, 1, 70, 1, 1, 0, .98  
220, 30, 0,0, 220, 1, 220,8

0, 1, 70, 1, 1, 0, .98  
145, 30, 0,0,

0, 1, 70, 1, 1, 0, .98  
89, 30, 0,0,

0, 1, 70, 1, 1, 0, .98  
37, 30, 0,0,

0, 1, 70, 1, 1, 0, .98  
104, 30, 0,0,

0, 1, 70, 1, 2, 0, .98  
80, 30, 0,0,

1, 1, 70, 1, 2, 0, .98  
83, 30, 0,0, 83,9

0, 1, 70, 1, 2, 0, .98  
80, 30, 0,0,

0, 1, 70, 1, 2, 0, .98  
80, 30, 0,0,

0, 1, 70, 1, 2, 0, .98  
80, 30, 0,0,

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80, 30, 0,0,

0, 1, 70, 1, 2, 0, .98  
80, 30, 0,0,

1, 1, 70, 1, 2, 0, .98  
59, 30, 0,0, 59,10

0, 1, 70, 1, 2, 0, .98  
80, 30, 0,0,

Citation: Butler, F.K. and E.D. Thalmann. CNS O<sub>2</sub> toxicity in closed-circuit SCUBA divers. In: Proceedings of the VIII Symposium on Underwater Physiology, edited by A.J. Bachrach and M.M. Matzen. Bethesda: Undersea Medical Society, 1984 + Original records.

0, 1, 71, 1, 2, 0, .98,  
17, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
18, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
22, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
18, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
19, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
18, 40, 0,0,

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18, 40, 0,0,

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18, 40, 0,0,

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18, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
20, 40, 0,0,

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20, 40, 0,0,

98



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15, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
15, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
15, 40, 0,0,

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15, 40, 0,0,

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15, 40, 0,0,

0, 1, 71, 1, 2, 0, .98,  
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.5, 1, 71, 1, 2, 0, .98,  
15, 40, 0,0, 15, 8,

.5, 1, 71, 1, 2, 0, .98,  
15, 40, 0,0, 12, 8

.5, 1, 71, 1, 2, 0, .98,  
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.5, 1, 71, 1, 2, 0, .98,  
15, 40, 0,0, 15, 2

.5, 1, 71, 1, 2, 0, .98,  
15, 40, 0,0, 15, 5,

Citation: Butler, F.K. and E.D. Thalmann. CNS O<sub>2</sub> toxicity in closed-circuit SCUBA divers. In: Proceedings of the VIII Symposium on Underwater Physiology, edited by A.J. Bachrach and M.M. Matzen. Bethesda: Undersea Medical Society, 1984 + Original records.

0, 1, 71, 1, 2, 0, .98,  
60, 25, 15, 40, 60, 25, 0,0,

0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	60, 25,	0,0,
0, 1, 71, 1, 2,	0, .98,	
40, 25, 0,0,		
1, 1, 71, 1, 2,	0, .98,	
60, 25, 15, 40,	0,0,	75, 8,
0, 1, 71, 1, 2,	0, .98,	
120, 25, 25, 40,	0,0,	
0, 1, 71, 1, 2,	0, .98,	
120, 25, 25, 40,	0,0,	
0, 1, 71, 1, 2,	0, .98,	
120, 25, 25, 40,	0,0,	
0, 1, 71, 1, 2,	0, .98,	
120, 25, 25, 40,	0,0,	

0, 1, 71, 1, 2, 0, .98,  
 120, 25, 25, 40, 0,0,  
  
 0, 1, 71, 1, 2, 0, .98,  
 120, 25, 25, 40, 0,0,  
  
 0, 1, 71, 1, 2, 0, .98,  
 120, 25, 25, 40, 0,0,  
  
 0, 1, 71, 1, 2, 0, .98,  
 120, 25, 25, 40, 0,0,  
  
 0, 1, 71, 1, 2, 0, .98,  
 120, 25, 25, 40, 0,0,  
  
 0, 1, 71, 1, 2, 0, .98,  
 120, 25, 25, 40, 0,0,  
  
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 13: 193-223, 1986 + Original records.

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240, 25, 0,0,

Citation: Butler, F.K. and E.D. Thalmann. CNS O<sub>2</sub> toxicity in  
closed circuit SCUBA divers II. Undersea Biomed. Res.  
13: 193-233, 1986 + Original records.

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120, 20, 10, 50, 110, 20, 0,0, 131, 5

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120, 20, 10, 50, 0,0, 130, 6,

Citation: Butler, F.K. CNS O<sub>2</sub> toxicity in closed-circuit SCUBA divers III Naval Experimental Diving Unit Technical Report No. 5-86, Panama City, FL: Naval Experimental Diving Unit, 1986 + Original records.

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